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Committee on Science
U.S. House of Representatives

The Impact of Federal Energy Efficiency and Renewable Energy R&D Programs

Presented by Paul Konove, President,
Carolina Country Builders of Chatham County, Inc.

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Madam Chairman and Members of the Subcommittee:

Thank you for conducting this important hearing and for inviting me to present my views on the potential of the building sector—and of energy efficient, sustainable single-family homes in particular—in meeting our nation's energy challenges. My name is Paul Konove, and I started Carolina Country Builders in 1985 in Pittsboro, North Carolina. I am honored to be here today on behalf of my company and also on behalf of the Sustainable Buildings Industry Council, also known as SBIC, an organization I first joined in the early '90s. The Council's mission is to advance the design, affordability, energy performance, and environmental soundness of residential, commercial, and institutional buildings nationwide. I am also a member of the National Association of Home Builders and my local home builders association.

This morning I will discuss the opportunities I see for the buildings sector—and home building in particular—to be part of a national strategy toward energy independence. From my experience as a home builder, my training as a mechanical engineer, and my involvement in the solar building industry over the last 19 years, I can tell you that sustainable buildings offer enormous potential for addressing our nation's energy needs. Moreover, they can contribute significantly toward solving other critical issues: housing affordability, water quality and supply, environmental protection, economic strength, and the health and safety of the American people. It is essential that builders and designers, government program administrators, and policy makers understand the importance of integrating energy efficient building technologies and renewable energy technologies if we are to achieve this goal for the buildings sector.

My company designs and builds custom homes in a two-county area that is part of the Triangle Region of North Carolina, which is the area around the cities of Raleigh, Durham, and Chapel Hill. My firm focuses mainly on new solar homes, although periodically we have built additions to existing homes. Nearly 100 percent of the new homes and more than 75 percent of the additions we have built rely on passive solar design, which I will address later. The homes have many different architectural styles, and the project budgets are diverse. Besides my design and construction work, I have been involved in solar energy education and training activities in North Carolina. To keep my business on the leading edge, I strive to be aware of national activities and building trends related to energy efficiency, renewable energy and sustainability. As a small-volume builder, I am representative of many U.S. home-building companies. According to the National Association of Home Builders, 68 percent of their members have four or fewer employees, and 15 percent of their members build 10 or fewer houses per year.

Madam Chairman, you asked me to respond to some specific and important questions about energy efficiency and renewable energy technologies in buildings. I am eager to give you my perspective as a home builder, and I am also proud to provide SBIC's perspective on these questions, a perspective resulting from a quarter-century of research and development of policy positions, publications, technical training, and other resources on "low energy", sustainable buildings.

Because of the complexity of building a home, as a builder it is easy to focus only on the immediate task at hand rather than the big picture of the entire project. But for nearly fifteen years, there has been a growing understanding from building scientists and others in the construction profession that the design and construction of a home needs to be addressed as a complete system. Therefore, I would like to address your questions in the context of a *"whole building" approach to design and construction*. Many architects, builders, home owners, commercial building owners, and policy makers are adopting a more holistic view of building design. Instead of viewing a building as a collection of discrete parts, they know that their home, school, or office building will perform better if it is designed as a *system* of *interrelated parts.* Of course, these parts must also perform well, and this is where R&D on specific technologies is also important. But it is *how we put these technologies together* that I believe, SBIC believes, and these forward-thinking architects, builders, owners, and policymakers believe, is what will truly advance the performance of buildings in the United States and enable the building sector to live up to its potential in meeting our energy needs, environmental challenges, and goals for affordable, comfortable, and healthful homes and buildings.

As defined in the Renewable Energy Policy Project (REPP) Research Report of September 1998, *Putting it Together: Whole Buildings and a Whole Buildings Policy*, "The whole buildings concept represents a method of siting, design, equipment and material selection, financing, construction, and long-term operation that takes into account the systems nature of buildings and user requirements. It treats the overall building as an integrated system of interacting components. Thus it is more performance-based than prescriptive."

As one of SBIC's workshop instructors puts it, there is no magic bullet that will make a building energy-efficient, cost effective, sustainable, comfortable, and healthful. There is no single product, material, or technology that will suddenly make the building perform well for those who breathe the air inside or pay the utility bills. While building product manufacturers are making amazing strides in the energy and environmental performance of their products, what is essential is how *all* the building components work together. Components should be carefully considered before the designer makes one sketch, and they should be selected based on how they will interact with the other

building components. These decisions should be based on *goals* for the project/home that the owners and designers establish in the earliest stages of programming and design. If these components are not chosen early on, it will be difficult, more costly, or perhaps impossible to complete a building that is energy efficient and/or that has superior indoor air quality and other "high performance" features.

The Sustainable Buildings Industry Council is one of the few (if not the only) organizations that brings many different buildings-related trade associations, architectural/engineering firms, utilities, consultants, product manufacturers, academic institutions, and builders together under one umbrella in order to advance the knowledge and create the user friendly tools that help designers and builders make complex decisions.

The Federal Government's Role in Buildings R&D

The building construction industry is highly fragmented, with hundreds of thousands of architects, engineers, contractors, subcontractors and construction workers, as well as a complex system of real estate investors, financiers, and owners. No one builder has more than 5 percent of the market (*Builder* magazine, 2000). The industry is both structurally incapable and economically unmotivated to take responsibility for the required level of whole building research and strategic coordination that can yield major economic and environmental benefits.

SBIC believes that a new, coordinated **U.S. Buildings Program** can bring together isolated building research programs throughout the government, integrate the full range of advanced building components developed by individual companies and organizations, disseminate the results of building science research conducted by government labs, and concentrate the efforts of diverse segments of the building industry. The program should consolidate various federal energy efficiency, solar and renewable technologies, and all other building-related programs into a single, integrated effort with a strong, clear vision of high-performance buildings in America's future. Only a coherent, long-term, nonpartisan research, development and deployment program on the national level can achieve the necessary next step in achieving better buildings and houses nationwide. As articulated in the REPP report**,**

A robust U.S. Buildings Program:

- Is based on a whole building approach
- Provides sufficient long term resources for professional training and public education

- Funds collaborative, fundamental, and applied research on building energy performance
- Partners with industry to stimulate demand for high-performance buildings through public awareness
- Supports development of prediction and verification tools for measuring building energy performance, cost effectiveness, environmental soundness, and other important attributes.

Industry-Government Collaboration

Industry needs to inform and contribute to this effort. Programs that foster industry-government collaboration are making great strides. The Department of Housing and Urban Development's *Partnership in Advancing Technology in Housing,* also known as "PATH", helps builders and consumers understand and adopt new housing technologies that help them attain various goals, including energy efficiency (www.pathnet.org). The U.S. Department of Energy's *Building America* program is teaching production builders how to build sustainably, cost effectively, and profitably. The DOE *Zero-Energy Buildings* program, also known as "ZEB," was established to fund projects that provide builders with new and innovative ideas on how to minimize residential energy consumption and use more renewable energy to power a home. The National Association of Home Builders Research Center worked with a builder who designed a home that is capable of achieving net-zero energy consumption. The Tucson Zero Energy Home was modeled with the energy analysis tool, *ENERGY-10*, and features active solar space and water heating, energy-saving fluorescent lighting, low-flow plumbing fixtures, Energy Star® rated appliances, a high efficiency air conditioner, radiant barrier roof decking, windows that minimize solar heat gain, and air admittance plumbing vents, among other energy efficient features. Because ZEB is one of the few federal programs that focuses on building integration, we were alarmed when it looked like it would get lost in the budget battle. Ironically, it fell through the cracks between the jurisdictions of the Appropriations Committee's Energy and Water Subcommittee, which funds DOE's solar programs, and the Interior Subcommittee, which funds DOE's buildings (energy conservation) programs.

And now to your specific questions…

1a. What are the key technology improvements that can result in cost-effective savings in today's homes and buildings?

In my opinion, there are a number of *strategies,* made possible by improvements in technology, that improve the performance of houses we build today. Many are cost effective now. Here are some that are included in SBIC's *Green Building Guidelines:*

Meeting the Demand for Low-Energy Resource-Efficient Homes (4th Edition).

1) Community and Site Planning

This is not a technology, but it sets the stage for the rest of the project: Proper orientation of homes and of streets and lot layouts in a development are critical for achieving optimal solar access and encouraging the use of site-generated solar energy. In addition, incorporating sustainability principles in community and site planning, such as increasing density, locating new development on infill sites to be near schools, shopping, and public transportation, and clustering homes and buildings to reduce infrastructure and preserve undeveloped land, helps to protect our nation's valuable natural resources.

2) Renewable Energy

If solar access and proper orientation are provided, passive solar design and solar hot water technologies are cost effective today. Building analysis tools such as *Designing Low-Energy Buildings with ENERGY-10* software have been helpful in determining how much passive solar design to incorporate into various projects. I have found these analysis tools are also helpful when discussing design, materials, and cost issues with my clients. Potentially complex issues can be presented in easy to read, graphical format.

3) Building Envelope

Air infiltration control has become a critical issue in housing. There have been technological improvements in recent years in the quality and longevity of caulks and sealant products used for this work. This work is not expensive and allows HVAC systems to be sized smaller (or "right-sized"), which balances out extra costs spent on tightening up a home. HVAC systems have been improved as well. We now have variable speed fans and much more efficient systems than even just a few years ago. Foundations, exterior walls, and windows are utilizing innovative new technologies that now allow for much greater building efficiency. Examples of these products are structural insulated panels (or SIPs), also known as stress skin panels, and insulating concrete forms (or ICFs) for exterior walls, and windows with high-performance glazing. Depending on why and how these products are used, they may be cost competitive with conventional products. I believe they are all poised for more widespread integration into the construction industry.

4) Energy Efficiency

Installing ductwork within the envelope of the home, insulating it sufficiently, and making it tight are excellent energy saving techniques. A blower door test and a duct blaster test have been developed to determine the quality of the installation and extent of air leakage. These test methods, plus more highly efficient equipment, help ensure that consumers are getting what they are paying for.

Compact fluorescent lighting (both fixtures and lights) are now more available at affordable prices, even at large building material retailers. There are numerous energy efficient appliances available on the market, and the Energy Star® program is helping consumers identify these products. I recommend to clients that they investigate these products.

Manufacturers of traditional and innovative building products, many of whom are members of SBIC (**http://www.sbicouncil.org/about/members.html**), are meeting the needs of sustainable building designers. These designers are creating buildings that save energy and provide comfort and health for their occupants, because they are integrating excellent products early in the design process. They are also using energy analysis tools to ensure cost effective design. For efficient buildings to become the norm, however, designers and builders must be able to estimate whole building performance confidently. Designers must have *verification and demonstration* that the individual products and systems have been combined and installed with a whole building approach and are cost effective across a variety of climates and building types, in both new construction and retrofits.

1b. Are there renewable energy technologies that can be utilized in new construction in a cost-effective manner?

Passive solar design, which utilizes the local climate characteristic, allows the building itself to collect, store, and distribute energy from the sun and can provide space heating in the winter and space cooling in the summer. Those trained to apply passive solar design strategies can do this without adding to the design costs, and this design significantly reduces the need for purchased energy from nonrenewable sources. Passive solar homes have been built across the United States for more than 30 years.

Solar water heaters installed in new homes can provide about 50 percent of the hot water needs of a typical family, and, if included in the mortgage, can have a net positive

impact on the monthly payments. Solar water heaters are a mature technology and are widely used throughout the United States.

Photovoltaic systems installed in new, energy efficient houses can provide a portion or all of the electrical energy. This may even be considered a cost effective technology if it's included in the mortgage (in states that have financial incentives) and/or if a portion of the power generated is sold back to the utility company (for example, during the day when the home's energy needs are minimal).

2a. What has your experience been with constructing high-efficiency buildings?

The first home in which I consciously incorporated this whole building framework was completed in 1991. I participated with the architect and the owner as a member of the design team. The result was a home that included the following features:

- Passive solar design
- Advanced framing
- High insulation levels and minimization of air infiltration
- Efficient heating and air conditioning equipment
- Low-flow plumbing fixtures
- Efficient lighting through extensive use of compact fluorescents and energy efficient appliances
- Recycling center
- Materials that were chosen for longevity and minimal off-gassing
- Preparation for the installation of solar hot water in the near future (since at that time North Carolina's solar energy tax credits discouraged more than one completed solar system per year)

Since that project, Carolina Country Builders has continued to use these strategies and to incorporate new products and strategies as much as possible, all with an awareness of the impact on the design and cost of the project.

2b. What have been the successes and the challenges?

An important thing I have learned from my experience is that the potential of energy efficiency and renewable energy strategies is not limited by design style or project cost. Another is that if these strategies are not incorporated into the planning process for both design and construction, they will be difficult to include at a later date, and will likely be more costly than if included from the beginning. One of the surprising things I learned about building passive solar homes resulted from my participation in the

National Renewable Energy Laboratory's Exemplary Homes Program. Our own home was monitored for a year under that program. The results convinced us that passive solar design kept us warm in our cold winters and contributed in substantial ways to keeping us comfortable even in the hot central North Carolina summers. It was not the temperature but the humidity that caused the air conditioning system to run. Because we used SBIC's design guidelines when designing our home, we also have better natural ventilation and substantial cost savings on summer electricity bills. The rule of thumb is that 7 percent of the home's floor area should contain operable windows. Since most of the new housing will be built in the South (according to *NAHB State and Metro Building Permits, March 2004* "Building Permit Activity for 2003"), I believe this is an important lesson to share with others.

Through the years, I have had both employee and subcontractor turnover. I am continually pleased to find people who are interested in working on and learning about the homes I build. But when I have to change subcontractors or find new employees, I have only a few to choose from who have the skills I require. Otherwise, I have to do on-site training.

Although this changes over time, one of my frustrations is that new products or techniques that are available in one portion of the country are not available in my location. I believe the reason for this is the lack of demand, which comes from a lack of awareness or training about the benefits and cost effectiveness of these strategies.

3a. What areas of energy efficiency and renewable energy technologies need research to improve their operation or cost effectiveness?

Passive solar, solar water heating, and photovoltaics are all ready for greater use. The biggest barriers are not technical in nature, but rather involve a lack of simplified design tools and awareness by both builders and customers. Volume production of solar water heaters would result in economies of scale, which I believe would create significant market growth. The next version of *ENERGY*-10 will be such a tool—combining energy efficiency, passive solar design, solar hot water, and PV in the same fast and accurate software package. The renewable energy portfolio standards that are becoming widely used in some states to encourage greater use of renewable energy often do not pertain to design strategies such as passive solar and technology such as solar hot water systems. Those policies should be expanded to include these strategies and technologies, as that will significantly open new markets.

There are probably many areas of energy efficiency and renewable energy that need research, but I am only familiar with a few. One is advanced thermal storage (or

plasterboard with integral phase change storage), which could enhance performance of passive solar homes while allowing builders to continue using conventional construction methods. I am aware that there is some work in the area of advanced electrically sensitive or switchable glazings that would reduce heat loss in winter and reduce heat gains in summer.

There is still a need for materials research, development and deployment and volume production to reduce the cost of photovoltaics. Lower cost inverters and lower cost battery storage will allow photovoltaic systems to provide stand-by emergency power, which is an especially valuable capability in terms of energy independence and building security systems.

SBIC believes there is an urgent need for research, development, and deployment (RD&D) in monitoring and verifying of building performance. As noted in the REPP report, and this remains true today, we must continue to invest in software tools that are fast, inexpensive to use, and accurate, and that permit easy analysis of building envelope and component alternatives, including the effects of their interactions. It is also important that the software gives design guidance, setting priorities on strategies that, in interaction with other approaches, deliver the highest or most cost effective return for the package. *ENERGY-10* is good, but it needs further development, such as the inclusion of PV as a design option, which has been planned for nearly 5 years. These tools must be supplemented by objective, well-documented case studies and demonstrations to validate computer models, provide monitored data on actual building cost and performance, and give confidence to both consumers and lending institutions.

3b. What technologies are ready for the marketplace but need improved technology transfer to be widely adopted?

Many of the energy efficient and renewable technologies my company and other builders around the country are using are cost effective today, but they are not widely used because builders are busy responding to their clients and do not have time to learn about new technologies. For an industry as important to the nation's economy as construction, there should be a coordinated strategy for educating and training those in the construction industry about these technologies and building methods. Achieving the integration of these methods into standard building practices will enable construction companies to be more profitable, provide consumers with more disposable income by saving on their utility bills, and help the national economy by keeping the construction industry strong.

Prior to being asked to testify today, I had an appointment scheduled this morning with a representative of a California-based developer planning to build a large mixed-use community in the county where I live. He is an active member of our local home builders association, an organization where we have had numerous educational presentations on green building products and strategies over the last two years. He asked to learn more about green building and how it might be applied in the developments they are planning, both local and otherwise. My point in mentioning this meeting relates to my perspective on deployment methods of energy efficiency and renewable energy for the construction industry. I would suggest that his interest was the result of continued local educational activity and the opportunity to come in contact with someone he thinks of as knowledgeable. There is a model for this type of technology transfer that has supported a vital member of our nation's economy for many years: The agriculture industry's cooperative extension service provides reliable information and training for our nation's farmers. Another model is the Manufacturing Extension Center program, which was established by the U.S. Trade and Competitiveness Act of 1988. I would think that the construction industry could benefit in a similar fashion.

SBIC has developed a number of programs to disseminate information to builders, consumers (*Green Building Guidelines* and seminars), K-12 school board members and administrators (*High Performance School Buildings Research and Strategy Guide* and workshops), federal project managers (workshops on *Low-Energy, Sustainable, Secure Building Design for Federal Managers*), and designers of small commercial buildings (*Designing Low-Energy Buildings with ENERGY-10* workshops). The Council has conducted hundreds of training activities, but this meets a fraction of the need. Those who procure buildings need to know how to ask for high performance, and building designers need to learn how to deliver it. Individual, community, state, and federal building decision-makers must be introduced to the benefits of whole building concepts, and architects, engineers, and building operators must be trained to understand how to pursue their trades in the context of whole building performance. At the very least, this will require the introduction and widespread dissemination of user-friendly whole building design tools that can lead owners and designers to sound decisions based on accurate simulations. Again, because of the fractured nature of the buildings industry, there is an important role for the federal government in developing software tools that no one group could develop alone and in providing education, training, and technology transfer programs that will help stimulate a transformation of the marketplace. It is also appropriate for the federal government to stimulate consumer demand for whole building designs that integrate efficiency and renewable energy sources.

4a. How do energy efficiency improvements in new construction differ from retrofitting older buildings?

In my opinion, all the energy efficiency strategies available to new homes can be used for existing homes, although some of the products, techniques, and/or their cost effectiveness may change. Renewable energy strategies are different. If the existing structure is not oriented correctly to take advantage of sun angles, it may or may not be feasible. Proper orientation for solar roof panels ensures optimal cost effectiveness and aesthetics. In recent years we have been installing more solar hot water systems on homes because of changes in the North Carolina tax law that allows for multiple systems to be completed within the same year. I am currently building a passive solar home where we will be installing both solar hot water and a 2 kilowatt photovoltaic system. I look forward to building a net zero energy home, but most builders are not yet ready for this. Their homes are not energy efficient enough to justify and support a renewable energy system. Here's an analogy: When doctors plan a heart transplant, they make sure that the body is in good enough health to receive the new heart. We should likewise have our housing in good health so that we can integrate renewable energy systems and build cost effective net zero energy homes.

With new construction, owners might have an ability to select a site that provides excellent solar access, and designers often have the ability to properly orient the building on the site. Existing structures may have existing conditions that are difficult or impossible to change.

4b. Given that about half the housing we expect to have in the year 2025 has not yet been built, what contribution can improved technologies make toward reducing the energy demands of the future housing stock?

Applying no-cost and low-cost *design principles* can lower the energy consumption of the future housing stock by 30 to 50 percent. By applying a whole building approach in the design and development of homes, we can realize improved comfort, water-efficiency savings, improved indoor environmental quality, and material efficiency. As stated in SBIC's *Green Building Guidelines*, a publication created by home builders for home builders, the millions of homes built every year require a combination of wood, concrete, glass, metal, and other products. These residential buildings consume approximately 20 percent of America's energy every year thereafter in the form of

energy consumption and maintenance needs. It is not necessary for our homes to be so energy and resource intensive.

There is enormous potential for savings in the home building sector. Buildings account for 36 percent of total U.S. energy consumption and two-thirds of the electricity used. Residential buildings represent approximately 55 percent of that. Heating and cooling consume the most energy in buildings. In residential buildings, water heating and refrigeration are the next biggest energy consumers, accounting for 24 percent of the energy consumed. (*Energy Research at DOE: Was It Worth It? Energy Efficiency and Fossil Energy Research 1978 to 2000,* http://books.nap.edu/books/0309074487/html/24.html 2001)

Currently, there are approximately 100 million residential buildings in the United States (EIA, 1996). The annual rates of growth and replacement of this building stock have been approximately 2 percent for residential buildings over the last 20 years (EIA, 1997). Thus, approximately 2 million new residential buildings and 200,000 commercial buildings have been constructed each year. (*Energy Research at DOE: Was It Worth It? Energy Efficiency and Fossil Energy Research 1978 to 2000,* http://books.nap.edu/books/0309074487/html/24.html 2001)

Wind, solar, biomass, and geothermal power, although growing, still supply only a tiny fraction of U.S. energy needs. In January 2000, however, the U.S. DOE's National Renewable Energy Laboratory released a report which said that the domestic PV industry could provide up to 15 percent of "new U.S. peak electricity capacity expected to be required in 2020." In 2002, shipments of solar PV cells and modules expanded by 15 percent, to around 112 megawatts, according to EIA's Renewable Energy Annual 2002. The average unit price of PV cells decreased in 2002 by 14 percent, to $2.12 per peak megawatt. Solar thermal collector manufacturing rose modestly in 2002, consistent with the general pattern seen since 1992 (except for a sharp rise between 2000 and 2001). Total shipments of solar thermal collectors rose 4 percent, to 11.7 million square feet. (US DOE Energy Information Administration - Country Analysis Briefs - USA http://www.eia.doe.gov/emeu/cabs/usa.html as of April 2004)

Sustainable building design benefits the environment. The United States, with the world's largest economy, is also the world's largest single source of human-caused greenhouse gas emissions. Quantitatively, the most important of these is carbon dioxide, which is released into the atmosphere when fossil fuels (i.e., oil, coal, natural gas) are burned. Current projections indicate that U.S. emissions of carbon dioxide will reach 5,985 million metric tons in 2005, an increase of 1,083 million metric tons from the 4,902 million metric tons emitted in 1990, and around one-fourth of total world energy-

related carbon emissions. (US DOE Energy Information Administration - Country Analysis Briefs – USA http://www.eia.doe.gov/emeu/cabs/usa.html as of April 2004)

Sustainable design makes homes more affordable. The average household spends 6 percent of its gross annual income on energy. For a low income household, this number is 12 percent. (Department of Health and Human Services FY 2000 Home Energy Data, http://www.acf.dhhs.gov/programs/liheap/notebook.htm)

Sustainable building design is important to our nation's economic health. Single-family and multifamily construction, plus remodeling, account for about 15 percent of the nation's total economic activity. During economic recoveries, housing's impact on the economy is even greater, accounting for up to one-third of the change in the gross domestic product. (NAHB 2004 Housing Facts and Figures**,** www.nahb.org). According to a report in April 2004 by researchers at the University of California at Berkeley, renewable energy promotes U.S. job growth better than investment in fossil fuels. The report states that investing in renewable energy such as solar, wind, and the use of municipal and agricultural waste for fuel would produce more American jobs than a comparable investment in the fossil fuel energy sources in place today. "Across a broad range of scenarios, the renewable energy sector generates more jobs per average megawatt of power installed, and per unit of energy produced, than the fossil fuel-based energy sector," the report concludes. In terms of net employment, the report states that "all states of the Union stand to gain from the implementation of a portfolio of clean energy policies at the federal level."
(http://www.eurekalert.org/pub_releases/2004-04/uoc--rep041304.php April 2004)

Sustainable building design is important to human health. According to the U.S. EPA, indoor air levels of many pollutants may be 2 to 5 times, and occasionally more than 100 times, higher than outdoor levels. Indoor air pollutants are of particular concern because most people spend as much as 90 percent of their time indoors. Children are especially vulnerable because of their small size and early stage of growth. Common sources can include burning kerosene, wood or oil, smoking tobacco products, releases from household cleaners, pesticides, building materials, and radon.
(http://www.epa.gov/air/concerns/)

Madam Chairman and members of the Subcommittee, I want to thank you for this opportunity to share my views and SBIC's perspective on sustainable building design. There is no doubt that buildings can be part of the solution to our energy challenges. I look forward to answering your questions and to continuing this dialogue.